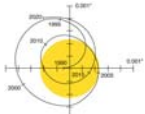


Using Interferometry to Achieve Micro-Arcsecond Astrometry

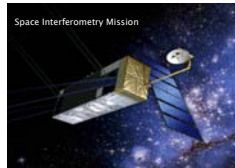
Bijan Nemati – Section 383

Why Micro-Arcseconds

The signature for an earth at 10 parsecs away is less than 1 microarcsecond.



Displacement of the Sun over 45-year period caused by Jupiter, as observed from 33 light-years away. The Earth is 318 times lighter than Jupiter.



Why Interferometry

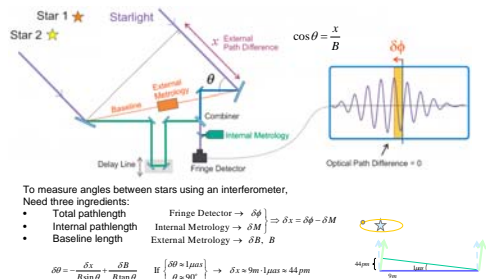
A 9m baseline interferometer with 30 cm apertures is equivalent to a 3 m telescope for astrometry.

In the special case of nearby exoplanet searches, an interferometer has a greater advantage. The 9m baseline interferometer with 2 deg FOR is like a 30 m telescope with a 12 arcmin FOV.

Adequate sampling of the telescope PSF for the purposes of uas astrometry requires giant focal planes – on the order of 1 Gpix (and mosaic focal planes may not do). Systematic errors in CCD centroiding for a focal plane that is critically sampled is probably limited to $(1/2000)(\lambda/D)$. A few tens of uas may be the limit for a 1-2 m telescope, goes linearly with diameter

The equivalent error for an interferometer is the measuring of the white light delay. Here a precision of $(1/60,000) * \lambda/D$ has been demonstrated in the laboratory.

Stellar Interferometer



Getting Down to Picometers

Noise

Atomic & Structural Vibrations :

Light beams average over large number of atoms on the optics surfaces

Vibrations along light paths are actively controlled to a few nanometers

Electronic Noise: Temporal averaging, low-noise electronic design

Thermal Drifts

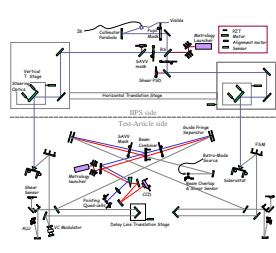
Affect Structure, Optics, Electronics

Chop between target and reference, or use repeat observations to remove linear temporal drifts

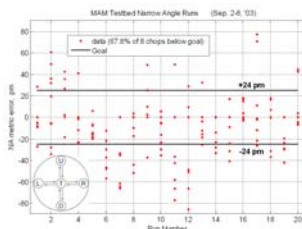
Systematic Errors

Field Dependent Biases: **Astrometric Grid** is used to solve for biases; Calibrations; Design

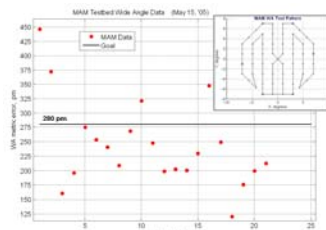
Micro-Arcsecond Metrology (MAM) Testbed



MAM narrow angle visits involve 4 stars in the same symmetric pattern used for Kite. The goal level NA performance is 24 pm. The performance metric used is the 8-chop average of the rms of the chopped delay differences. The data shown is from a five-day period, where MAM took 20 NA runs each containing six 8-chop visits.



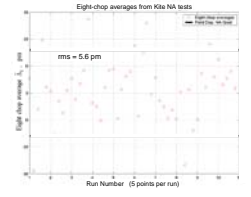
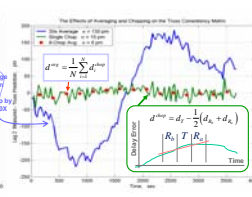
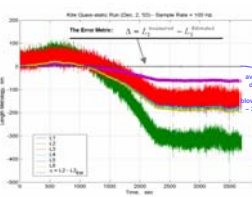
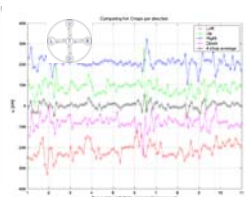
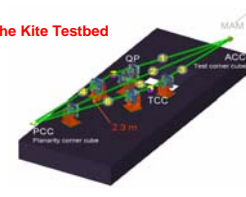
Sample set of MAM WA Data. Inset: A MAM wide angle test pattern. The green target at the center of the tile is used for linear temporal drift removal. The red marked targets on the perimeter represent grid targets.



Picometer Metrology Testbed (Kite)



The Kite Testbed



Expectations for SIM Performance

For planet finding, the SIM narrow-angle chop breaks down most errors into effectively random errors.

Instrumental errors in the SIM testbed (chopped) integrate down as \sqrt{T} at least down to 1-2 picometer after 10^5 sec

The floor may be constrained by available integration time.

